US Army Corps
of Engineers
Construction Engineering
Research Laboratory

USACERL TECHNICAL REPORT P-90/16
June 1990

Preventive Maintenance Program: Evaluation and Recommendations for Improvements

by
Donald K. Hicks

This report evaluates the Army Preventive Maintenance (PM) Program for buildings and structures, and utilities, discusses problems with the program, and recommends solutions. The evaluation describes preventive maintenance documentation and operating procedures, including the Self-Help (SH) Program for family and troop housing, analyzes the existing variations in performance of preventive maintenance, and looks at the quality of the existing preventive maintenance data and recordkeeping information as it is kept in the Integrated Facilities System (IFS) records.

The data obtained show that significant improvements could be made to the program and to the recordkeeping that would result in significant cost reductions to real property maintenance and repair costs. Based on the results of the analysis, recommendations are given for improving the existing preventive maintenance methods and procedures in resource management and decision support.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official indorsement or approval of the use of such commercial products. The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED

DO NOT RETURN IT TO THE ORIGINATOR

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 1990	Final

4. TITLE AND SUBTITLE
Preventive Maintenance Program: Evaluation and Recommendations for Improvements

5. FUNDING NUMBERS
IAO-E87880261 (dated September 1988)

6. AUTHOR(S)
Donald K. Hicks

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Construction Engineering Research Laboratory (USACERL)
P.O. Box 4005
Champaign, IL 61824-4005

8. PERFORMING ORGANIZATION REPORT NUMBER
TR P-90/16

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
USAEHSC
ATTN: CEHSC-FB-S
Ft. Belvoir, VA 22060-5516

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This report evaluates the Army Preventive Maintenance ~~(PM)~~ Program for buildings and structures, and utilities, discusses problems with the program, and recommends solutions. The evaluation describes preventive maintenance documentation and operating procedures, including the Self-Help ~~(SH)~~ Program for family and troop housing, analyzes the existing variations in performance of preventive maintenance, and looks at the quality of the existing preventive maintenance data and recordkeeping information as it is kept in the Integrated Facilities System ~~(IFS)~~ records.

The data obtained show that significant improvements could be made to the program and to the record keeping that would result in significant cost reductions to real property maintenance and repair costs. Based on the results of the analysis, recommendations are given for improving the existing preventive maintenance methods and procedures in resource management and decision support.

Keywords:

14. SUBJECT TERMS
~~Preventive Maintenance Program~~
preventive maintenance, Army Personnel, (CP)

15. NUMBER OF PAGES
39

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

FOREWORD

This research was conducted for the U.S. Army Engineering and Housing Support Center (USACEHSC), under Intra Army Order Number E87880261 dated September 1988, "Integrated DEH Preventive Maintenance System." The Technical Monitor was Mr. Michael Smith, CEHSC-FE-B.

The work was performed by the Facility Systems Division (FS), U.S. Army Construction Engineering Research Laboratory (USACERL). Dr. Michael J. O'Connor is the Chief of USACERL-FS.

LTC E.J. Grabert, Jr. is Commander of USACERL, and Dr. L.R. Shaffer is Director.

CONTENTS

TABLES

FIGURES

PREVENTIVE MAINTENANCE PROGRAM: EVALUATION AND RECOMMENDATIONS FOR IMPROVEMENTS

1 INTRODUCTION

Background

Performing preventive maintenance (PM) to reduce maintenance cost and interruptions caused by breakdown has been an integral part of the Army Maintenance System for many years. Preventive maintenance is a cost-saving, sensible practice now accepted by most industries. Many case studies could be developed to demonstrate the derived benefits and the impact on Army readiness. Over the years changes have been made in the program both to reflect the current needs of the Army and to accommodate changes in attitude and leadership. In view of the high cost of PM operations, however, the question is whether the Army is making good use of the program. The Army may be paying more for PM than it would cost periodically to replace broken equipment. Breakdown maintenance on many components and equipment may be inexpensive and not impact operations, thus eliminating the need for PM on these components. Is the Army making the best use of its maintenance resources?

Preventive Maintenance is divided into two broad categories: (1) Buildings and Structures and (2) Utilities. This report covers both categories. Within each category are four groups of task types (work codes): inspection, minor repair and service, reporting to the appropriate shop needed repairs that are beyond the scope of work for the PM team, and nonproductive, administrative, and travel/break codes. Part of the Preventive Maintenance Program is the Self-Help (SH) Program, in which the occupants of family and troop housing perform limited maintenance and repair work and minor improvements to their quarters.

Objective

The objective of this report is to analyze the existing Preventive Maintenance Program composition, recommend improvements to existing methods and procedures, and identify areas for further study, test, and evaluation.

Approach

A multiphased approach was used to provide in-depth analysis of the PM Program. Installation Directorate of Engineering and Housing (DEH) personnel, civilian property and Preventive Maintenance Program managers, and family housing (FH) Self-Help Program administrators were surveyed by site visits and telephone inquiries to obtain direct user input about the current program. Department of the Army (DA), Department of Defense (DOD), and Major Command (MACOM) documentation providing PM guidance, as well as previous research, was evaluated. Recommendations were made for improving the program based on the data analysis, DEH personnel responses, and commercial practices.

Scope

This report covers the first phase of a multiyear study to evaluate the program, to redefine its operations if necessary, to provide guidance on eliminating tasks that should not be included in the program, and to integrate the work with the Maintenance Management System (MMS) and other computer programs designed to assist maintenance managers.

Mode of Technology Transfer

Results of the study will be transferred to DEH organizations through documents, onsite technical assistance, and revision of Army Regulation 420-22, *Preventive Maintenance and Self-Help Programs* (HQDA, 6 July 1976) and supporting technical manuals (TMs).

2 DATA COLLECTION AND ANALYSIS

Evaluation of the PM program and recommendations for program change were based on intensive data collection. Information was gathered by (1) telephone interviews with PM personnel at 13 continental United States (CONUS) installations, (2) in-depth site visits to three installations, (3) telephone interviews with civilian property managers, (4) examination of Integrated Facilities System (IFS) records from 9 installations, and (5) review of previously published research. The information obtained was used to establish a baseline for comparison and evaluation.

Data Collection

Telephone Interviews with Installation Personnel

Telephone interviews with PM personnel at 13 CONUS installations were used to obtain baseline data and to help determine which installations would be visited for in-depth evaluations. Most often interviewed were the Public Works Directorate (PWD) chiefs, PM shop foremen, SH coordinators and service center managers, family housing (FH) representatives, and budget analysis personnel. Directorate of Engineering and Housing (DEH) office representatives provided information about the overall program, including the interaction between PM and SH, the general attitude toward PM's inclusion of SH, the mechanics of the PM Program including the SH aspects, and cost-reporting/accounting procedures. Discussions were also conducted with the Management Engineering Services (MES) branch of the DEH about the Maintenance Management System (MMS) and the Integrated Facilities System (IFS). PM foremen were interviewed to obtain information about (1) overlaps between the PM and SH programs, (2) policy directing PM team members' efforts and responsibilities regarding FH, and (3) the incidence of the need to rework incorrectly completed SH tasks. SH service center managers and foremen provided detailed information about daily SH operations.

Site Visits

Three sites were chosen. Many factors were considered during the selection process, including physical size, geographical locations, major command (MACOM) affiliation, PM management style and philosophy, high ratings (by their respective MACOMs) of PM Programs, and the completeness of the IFS recorded data.

During each site visit, personnel associated with the following DEH activities were interviewed: PM, FH, SH, budgeting, supply, MES, and repair and maintenance. At installations using Commercial Activities (CA) contracts, personnel doing quality assurance evaluation of the contracted maintenance were interviewed. The site visits provided a significant amount of detailed information. They also gave researchers firsthand impressions and subjective evaluations that contributed to understanding of the less quantifiable issues underlying implementation of a successful program.

Telephone Interviews with Civilian PM Managers

Telephone interviews were conducted with maintenance managers of several major industrial and commercial corporations and a large university regarding their approach to preventive maintenance. The conversations were enlightening about how nonmilitary organizations conduct preventive maintenance programs. Discussions and telephone interviews were conducted with a large public university, a

multinational coatings and adhesive manufacturer, an international fast-food franchiser, and a U.S. automobile manufacturer.

IFS Record Analysis

IFS records stored on machine readable data tapes were acquired from nine U.S. Army installations. IFS records for FY85 and FY86 were reviewed for all installations. Based on the relative completeness of IFS data, site visits, geographical location, and telephone conversations with DEH personnel, three sites were chosen for further study and analysis of their PM efforts. FY86 IFS data for Fort Eustis, Fort Devens, and Fort Bliss were selected.

Previous USACERL Research

Previous research[1] conducted and published by USACERL into the PM and SH function of the DEH was reviewed, and investigators were consulted. The results of these consultations were incorporated into this report as appropriate.

Quality of IFS Data

As explained below, IFS system data are not considered highly accurate, and analysis and findings based on such data reflect its inaccuracy. In contrast, this report focuses on general rather than specific aspects of PM. IFS data appear to be sufficiently accurate to define patterns and trends and, thus, will be used for that purpose.

The data recorded in IFS were investigated and found not to represent work performed. PM team operations were observed in the field at several installations. Workers reported enough tasks to justify their workdays and distributed their time accordingly. In addition, workers performed several more tasks each day than the number reported. In the workers' opinion, because no one used the time-per-task figures, concern about their accuracy was unnecessary. They saw confirming that they had worked a full day as the only significant item to report. If this is common practice, the reported labor hours are overstated.

Some installations, however, manage their crews dynamically using radio communication. Task performance is compared with the Engineered Performance Standards (EPS)*. If the lapsed time exceeds the EPS, a dispatcher asks workers to explain the delay. The dispatcher assigns new tasks once workers have completed other tasks. Data from these installations may be more accurate but workers may perform small tasks not recorded in a normal workday. On other installations, workers are thought to stretch the time per task to fill the day, with resulting low productivity. Given this variety of conditions, the present assessment is based on the assumption that the reported data is accurate and appropriate enough to serve as the basis for recommending program changes.

---

[1]J.H. Williamson, J.E. DeLong, C.J. Norris, and S.E. Glaeser, *Family Housing Self-Help Program: Evaluation and Recommendations for Improvements*, Technical Report P-86/08 ADA171466 (U.S. Army Construction Engineering Research Laboratory, July 1986).

*TB 420 Series.

Results of Data Analysis

Telephone Interviews and Site Visits

Preventive Maintenance. The PM program is in place and working to some degree at all the installations surveyed. The degree of involvement seems to depend on the availability of personnel and funds for PM. Because PM is part of the more inclusive Real Property Maintenance Activity (RPMA) program, some installations have shifted their PM focus from inspection to repairs. This approach reduces the probability that the program is working as intended, that is, eliminating repairs through PM inspection and maintenance. This action also represents a significant philosophical change regarding PM.

Self-Help. SH programs are used primarily in family housing, although some SH projects are done in troop housing and other buildings. SH is expanding to include various improvement programs such as "U-DO-IT," for small remodeling and addition projects. The degree of complexity varies with labor skills and installation funds available for such projects.

Management. Management of PM varies from installation to installation according to management styles, installation organization, and other poorly defined criteria. Some factors influencing management are administrative attitudes on relative value of PM, budget considerations and constraints, the impact of CA studies, staffing levels, and previous experiences in PM program management.

Organization. The organization of PM varied from installation to installation and, in some cases, from year to year on the same installation. In most cases, however, PM fell into one of the following categories:

- Conventional: The PM mechanic or team inspects a facility, makes minor repairs, and reports larger repair requirements for service order repair action.

- Spot fires: Very little PM is accomplished; the mechanics primarily respond to emergency calls, which occupy most available time.

- Iceman: PM mechanics cruise areas of family housing. If occupants need PM services, they display a card in the front window. The PM mechanic contacts the occupant and arranges for the PM work.

- Radio controlled: PM mechanics are directed to each call by a dispatcher using a two-way radio system; PM mechanics are directed to emergencies as they arise.

- Other: These are combinations of the above categories.

Budget. The budget for PM is perceived vulnerable to funding cuts because it lacks demonstrable benefit. In addition, PM program managers are unable to show hard data on the results of the PM effort to the budget administrators because data do not exist or are not in usable form.

Support. Most DEH and PM program managers agree that PM is cost-effective and needs to be expanded to have demonstrable benefit. Being able to demonstrate clearly positive results of PM will contribute significantly to informing those who make decisions concerning the PM Program.

Training. The Army hires people for PM work who have considerable maintenance and repair experience. No formal training program exists for newly hired mechanics. Less experienced mechanics learn specific shop procedures and techniques from senior mechanics. Interviewees indicated that formal training would be beneficial for PM mechanics servicing buildings, structures, and utilities.

Supervisors and mechanics indicated, moreover, that most PM documentation is outdated and nonspecific. For example, the current PM manual for kitchen equipment, TM 5-637, was published in July 1945. The expressed need was for revised technical manuals with specific guidance for conducting inspections and other PM tasks (e.g., "calibrate the thermostat" rather than vague statements like "check thermostat"). The consensus was that improved manuals would upgrade the effectiveness of PM.

The Civilian Approach to Preventive Maintenance

Maintenance personnel at private institutions/industries were interviewed by telephone. They provided information on preventive maintenance programs at the corporate and/or local level. PM practice varied widely among these firms.

Auto Manufacturer. The auto manufacturing company had two extremes of PM. At the corporate headquarters PM was not practiced; instead, breakdown maintenance was relied upon. The decision to use the breakdown approach was based on an estimated lack of return on the investment (ROI) needed to maintain a formal PM program and a belief that maintenance problems would not cause a loss in staff productivity. However, at the company's manufacturing and assembly plants, formal PM programs using computer-generated PM work schedules were in place.

The initial framework for the computer-based data management system was developed by the corporation. Local maintenance personnel added information about buildings and equipment, type and amount of PM required, and task performance frequencies. The computer generates a maintenance card daily for each mechanic detailing the day's tasks. After the mechanic completes all tasks and so notes on the card, he returns it and this data is recorded in the program. Unfinished tasks are listed on the next day's card of tasks, which ensures that specific tasks do not appear more than once during a cycle. Individual PM systems constitute a network that allows information sharing between local installations. Thus, if one installation sets up a program for a given piece of equipment, another installation can input the information into its system. This design was in place at an automobile assembly plant, where a breakdown or interruption of service would have resulted in substantial productivity loss.

Fast-Food Franchiser. At the surveyed fast-food restaurant company, corporate-level personnel developed the PM schedule listing task description and required PM frequencies for each piece of equipment for local restaurants. The program is described in detail in various manuals provided to restaurant managers. Buildings and equipment were usually set up on 6-month PM cycles. Restaurant managers set up an annual calendar for completion of tasks. Maintenance personnel work from a daily PM task list. Preventive maintenance is performed according to detailed guidance given in the equipment manuals. Most of these PM inspections are performance related, if the item does not meet specified performance levels, equipment repair and adjustments are made. This type of PM program is very efficient because buildings and equipment are standardized and the corporation exercises considerable control. As in the case of the auto assembly plant, a breakdown would result in lost production and revenue, and possibly a loss of reputation.

Adhesive Manufacturer. The international coatings and adhesive manufacturer is setting up a company wide PM program. Currently, each plant operates its own minimal PM. These programs are based on insurance carrier requirements and consist of inspecting fixed fire equipment, overhauling major electrical systems every 3 years, and inspecting the roofs every 5 years. Most of the work is performed by contractors specializing in PM. The contractor establishes and proposes a schedule for PM work, the corporation reviews and approves the schedule and makes periodic quality assurance inspections. A PM scheduling program now being developed will be computer-generated and more inclusive than those currently in use.

Public University. The university in the survey practices extensive PM, which is accomplished using teams organized by task types. For example, a team of mechanics walks the underground utility tunnels daily looking for breakdowns and potential problems, such as leaking water or steam pipes. Building inspections are conducted on 3- to 5-year intervals with teams consisting of a general inspector, a mechanical inspector, and an electrical inspector. The team has the authority to request up to $2,500 worth of immediate repairs to alleviate a hazardous or potentially dangerous situation. Inspection teams also report housekeeping problems, relating primarily to health and safety, to the various department heads, who are responsible for correcting the problems. Roofs are inspected, and records of the moisture content of the roofs are kept to determine if the roofing system has deteriorated since the last inspection. Based on this data, appropriate repair/replace actions are taken. Air-conditioning and air-handling filters are checked periodically. Cooling towers are serviced in the fall for shutdown and winterization and in the spring for start-up. Building elevators are serviced and cables lubricated. Adjustments to elevator doors are made twice a year and are scheduled in advance of official building inspections. General illumination lamps are changed en masse after 10 to 15 percent of the lamps have failed in an area. A vibration team checks reported building vibrations, identifies the source of the vibration (usually in the mechanical equipment) and makes appropriate repairs.

The manufacturing/assembly PM program is closely related in structure to the Maintenance Management System (MMS) that is installed (or scheduled to be installed) and is currently being tested at Fort Ord, CA, Fort Jackson, SC, Fort McCoy, WI, and Fort Eustis, VA. The primary difference between the two systems is that the MMS does not have the capability to share information with other installations. Adding this capability to the MMS would be beneficial, especially for installations placing new equipment in the PM program. If one installation already has this equipment type in its PM program, the installation just acquiring it could benefit from the first installation's experience in setting up its own PM tasks.

Integrated Facilities System (IFS) Record

The IFS data for three sites for FY86 were analyzed to determine the following information:

1. Total monthly and annual cost of PM performed by DEH mechanics according to civilian and military labor costs, shop stock supply and nonshop supply costs, equipment rental and depreciation costs, and other costs.

2. Total monthly frequency of PM tasks according to equipment type, installation number, and building/facility number.

3. Frequency of PM tasks versus frequency of repair according to date, total cost, equipment type, installation number, and building number.

4. Total monthly and annual cost of PM for all family housing units.

5. Monthly frequency of PM in family housing, broken down by task, labor cost, material (supply) cost, and equipment cost (rental and/or depreciation).

6. Average cost and labor hours associated with each PM task (because each installation is allowed to define its own task codes independently, these averages will have to be developed for every PM task defined by each installation).

7. Labor hours and cost of tasks performed by the PM shop personnel which the occupants could have performed (i.e., self-help tasks).

This information was correlated, charted, and analyzed to determine the status of PM at the selected sites.

During the data collection period a number of the selected installations were in some phase of the commercial activities (CA) review process. IFS information was not available from these installations due to the sensitivity of the data in the CA process. Also, contacts indicated that CA studies influenced how mechanics and supervisors recorded labor and equipment data for PM activities. It was found that at installations under CA review, workers made an effort to record performance data more accurately.

The level of detail recorded in IFS data at some installations was inadequate for CA studies. As a result, IFS was either altered or abandoned at those sites. At Fort Eustis and Fort Bragg a more thorough analysis of ongoing work was needed for CA studies. Originally, a two-character numeric code was used for coding tasks. This system limited the user to 100 task descriptions. Fort Eustis changed to a two-character alphanumeric code. Now more task descriptions are available for each shop. The analysis used in this report is based on the expanded coding system.

Fort Bragg also modified the IFS to make it more useful. IFS will allow only three task codes to be entered under a single service order; more than three will result in an error message. By increasing the number of task codes per service order, Fort Bragg would generate a more accurate analysis for the purpose of CA studies. dBASE III is used to generate work order history files. Their IFS data is complete except for task codes which are recorded separately in the dBASE files.

Also, some changes in maintenance work procedures have resulted from CA studies. Concern about losing their jobs to commercial contractors has made foremen and workers more efficiency-oriented. They frequently change work methods, scheduling, and other aspects of their work to improve productivity. If one looks at IFS data for a given year, what appear to be peaks or lulls in frequencies, costs, or labor hours may actually reflect operational changes. In some cases, work force size has diminished due to CA studies. PM personnel openings often are not filled to reduce operating cost and be more competitive with commercial contractors.

3 PREVENTIVE MAINTENANCE PROGRAM

Program Overview

The PM and SH programs are mandated by Army Regulation (AR) 420-22[2] and are defined as follows:

> Preventive maintenance is the systematic care, servicing, and inspection of equipment, utility plants and systems, buildings and structures, and ground facilities for the purpose of detecting and correcting incipient failures and accomplishing minor maintenance. . .
>
> The Self-Help Program involves military personnel and occupants of family/troop housing in accomplishing limited maintenance and repair work and minor improvements in family housing. . .
>
> *Installation commanders* are responsible for the programming and accomplishment of the preventive maintenance program and for establishing and administering the self-help program at installations under their jurisdiction. . .
>
> The facilities engineer is responsible for providing technical guidance and assistance to participants in these programs. . .

As shown in Figures 1 and 2, the costs of maintaining family housing and all real property have risen dramatically in recent years. Because maintenance costs include PM costs, and because PM costs have risen correspondingly, a significant effort toward making overall PM more efficient and cost-effective is necessary.

Requirements

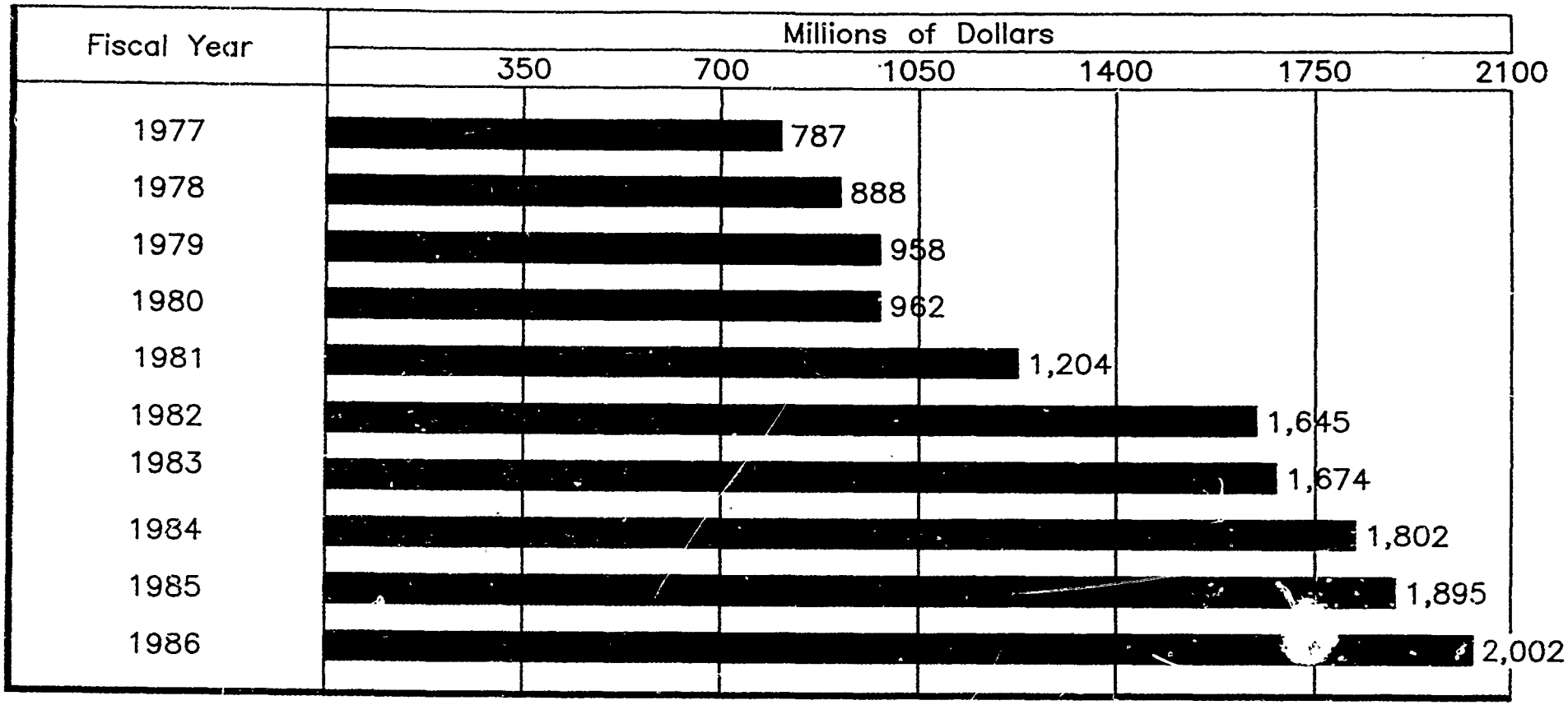
Description of Current Documentation

Guidance documentation and regulations for the PM Program are defined in the Technical Manual (TM) 5-600 series and supplemented by DA[3] and MACOM[4] publications. Occupant guidance for the Self-Help Program is provided in the same DA pamphlet and in technical bulletins.[5]

Preventive maintenance requirements for buildings and structures as detailed in the TM 5-600 series, consists of inspecting building component conditions and preparing work orders. Timing and phasing are not considered in the inspection task list for buildings and structures, which is enumerated in

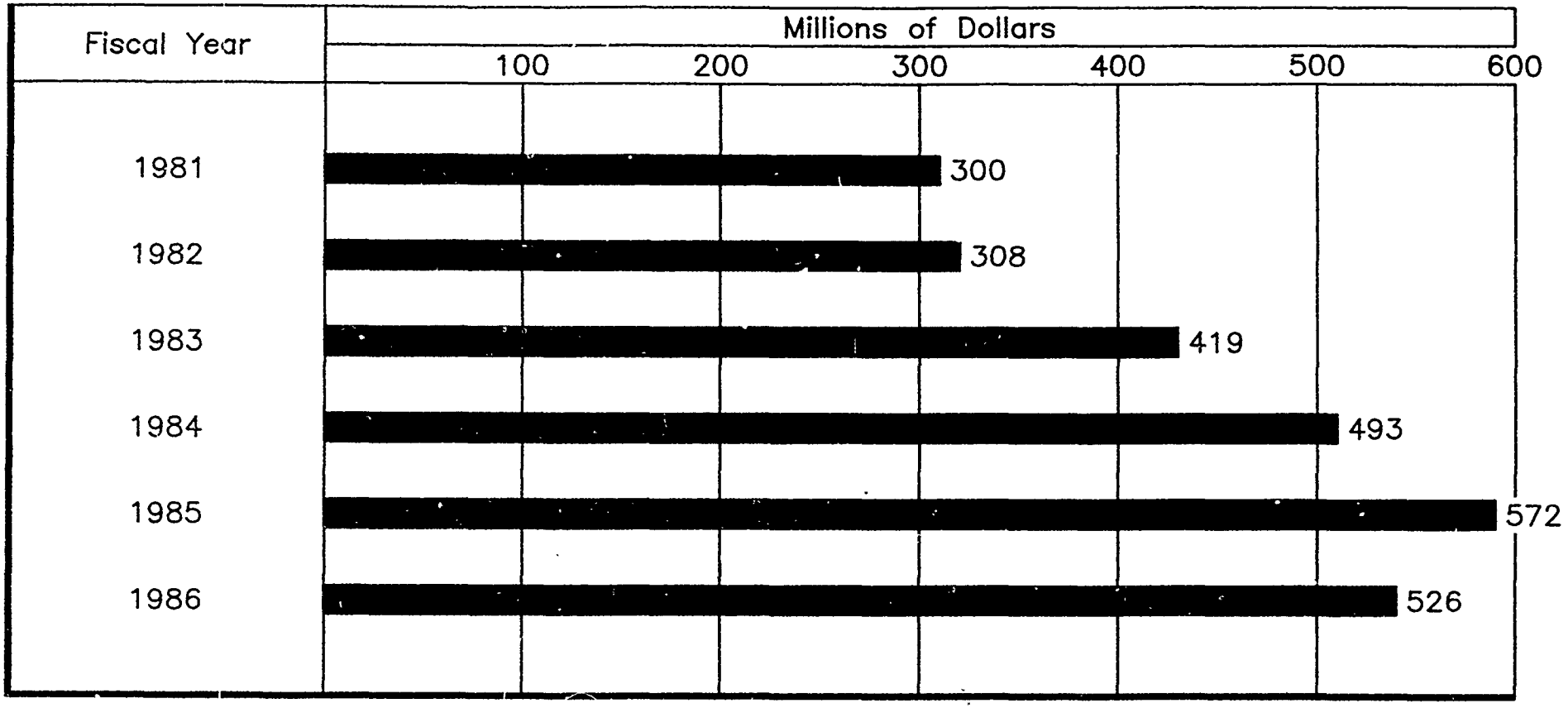
---

[2]AR 420-22, *Preventive Maintenance and Self-Help Programs* (HQDA, 6 July 1976).
[3]DA Pamphlet 210-1, *Handbook for Family Housing Occupants* (HQDA, 15 September 1971).
[4]TRADOC Regulation 420-5, *Preventive Maintenance and Self-Help* (U.S. Army Training and Doctrine Command, 11 June 1982).
[5]Technical Bulletin ENG 402, *Facilities Engineering Self-Help Program* (HQDA, 16 July 1970).



- During this 10–year period maintenance and repair of real property costs increased by $1,215 million or 154.4 percent ($2,002 vs. $787 million).
- The average increase was $122 million or 15.4 percent per annum.
- The largest increase took place in Fiscal Year 1982 – $144 million or 36.6 percent above Fiscal Year 1981 ($1,645 vs. $1,204 million).
- In Fiscal Year 1986 maintenance and repair of real property costs increased by $107 million or 5.6 percent above Fiscal Year 1985 ($2,002 vs. $1,895 million).

Figure 1. Maintenance and repair of real property cost trends.



- Army Family Housing — Maintenance rose from $300 to $526 million from Fiscal Years 1981 through 1986 — an increase by $226 million or 75.3 percent.
- Annual increases from Fiscal Years 1982 through 1985 were as follows:
  - $8 million or 3 percent in Fiscal Year 1982.
  - $11 million or 36 percent in Fiscal Year 1983.
  - $74 million or 18 percent in Fiscal Year 1984.
  - $79 million or 16 percent in Fiscal Year 1985.
- In Fiscal Year 1986 Family Housing — Maintenance decreased by $46 million or 8 percent below Fiscal Year 1985.

Figure 2. Army family housing maintenance trends.

TM 5-610.[6] The utilities task list (see, for example, TM 5-637[7]) emphasizes performing tasks to improve equipment operations, including changing filters, making minor adjustments/replacements, and inspecting for major repairs.

Each installation defines PM according to its perceived requirements, its managers' personalities, and local tradition. To illustrate the varying perceptions of which tasks are to be performed, Appendix A lists the standard PM task codes and task descriptions for the surveyed installation for door PM.

In general, PM for buildings and structures has changed from being primarily inspection to performing minor repair. Organization of shops and crews varies widely, but always includes a team specializing in performing preventive maintenance on buildings and structures. Skills represented on the team indicate management's emphasis in this area.

Evaluation of Current Documentation

The TM 5-600 series of technical manuals for the PM Program is antiquated and inadequate for today's requirements. Some of this information dates back to the mid-1940s and discusses equipment and procedures of that era. Given technological advancements of the past 40 to 50 years, far better guidance and documentation can be provided. For example, PM mechanics now rely primarily on service recommendations provided by the equipment manufacturers. Because building equipment is not standard in an installation, mechanics maintain several makes and models of each equipment item and must be familiar with their service requirements. This lack of standardization is the result of using competitive contracts, and the practice complicates maintenance activities.

Program Execution

Fort Bliss

The PM shop staff consists of 23 mechanics (two master plumbers), four locksmiths (two temporary), and one shop supervisor. The master plumbers' salary grade is higher than that of the other PM shop mechanics. A team of PM mechanics spends the first half of the week working in troop housing and the rest of the week inspecting and repairing recently vacated family housing units with the rest of the mechanics. No cyclic PM is performed for family housing; repair and maintenance services must be requested from the work order desk. Cyclic PM occurs only in troop housing and post buildings.

PM operations in a typical utility shop are similar to those of the refrigeration shop, which has one foreman, three leaders, one clerk, three emergency mechanics, and 15 specialized mechanics. Each mechanic is assigned a geographic area of the post. In the morning a mechanic inspects part of the facilities in that area. (This is not a PM inspection, but rather a search for repairs.) The mechanic returns in the afternoon to make the repairs. The day ends with another inspection of the same facilities to determine if all the work was completed; if not, it is rescheduled for the following day.

This shop is working with less than half the staff it had 10 years ago. Nevertheless, by using the inspection systems, the mechanics identify and correct problems before breakdown failures occur, thus reducing total operational costs and saving time. Despite the efficiency of the inspection systems, however, labor shortages persist and much of the work is contracted out. For example, all filter

---

[6]TM 5-610, *Preventive Maintenance: Facilities Engineering, Buildings and Structures* (HQDA, 1 November 1979).
[7]TM 5-637, *Inspection and Preventive Maintenance Services for Kitchen Equipment* (HQDA, 25 July 1945).

replacement and over 70 percent of maintenance on evaporative coolers are contracted out. One mechanic is responsible for the performance and quality inspection of all work done by contractors.

Fort Devens

Cyclic PM is done on both administrative and billeting cantonement (i.e., winterized and occupied year-round) structures. The facilities PM force is made up of 17 men: 14 PM mechanics, two working leaders (one for FH/TH and one for administration buildings), and the PM shop supervisor. The force is divided into 10 teams. Four one-person teams work in FH, and each is permanently assigned to a certain area. Family housing PM work is performed when a displayed PM card is seen, by appointment, or by service order. Four teams perform PM on administrative and billeting facilities. Two one-person teams work on administrative buildings and two two-person teams work on barracks. Each of these four teams works in an assigned area and completes a PM cycle every 16 weeks.

Fort Devens has six utility shops, and most utilities PM is done annually. Boilers and heat plants are inspected and maintained in the summer, and air-conditioning and refrigeration units are primed in the winter. The water distribution system is checked and maintained throughout the year as needed (e.g., the valves are exercised twice a year). A line crew continuously maintains the electrical distribution system. The utilities PM work is funded via long-phased individual job orders (IJOs), and each year an IJO is issued for PM specific to a certain type of equipment. For example, an IJO is issued at the beginning of the fiscal year to inspect and maintain all boilers, and the work is completed throughout the year.

Fort Eustis

The PM shop, along with eight other shops, is responsible for the performance of PM for buildings and related utilities. The tasks of the PM mechanics are limited in size and skill level and are usually performed in family housing (FH), troop housing (TH), and post buildings.

The PM shop staff has been reduced from 22, an all-time high 12 years ago, to its current size of 9 mechanics. PM shop mechanics cover an assigned area of the post. The two two-person post buildings teams split the more than 500 permanent, semipermanent, and temporary buildings between them. One team covers the northern half of the installation, and the other, the southern half. The four FH teams cover a roughly equal amount of the 1335 FH units. The two-person FH team (the others are single-person teams) is assigned to the older units, which require more maintenance.

Cyclic maintenance is scheduled for post buildings and FH units. Post buildings are on a 180-day cycle, FH units are on a 120-day cycle. Each week a list of the buildings and FH units scheduled for PM is printed in the post bulletin. Typically, a family housing PM mechanic will begin his day by correcting deficiencies in vacant quarters the day after the occupants' household goods have been removed. (Fort Eustis requires occupants to schedule a PM visit after the quarters have been inspected by family housing personnel and before clearing.) After the mechanic has made his scheduled PM calls to inspect vacant FH units, he responds to work orders and displayed PM cards as time permits. The PM card is a displayed signal device, which is included in the FH packet given to new occupants upon arrival. These cards are placed in a street side window of a unit when a PM mechanic is scheduled to be in the area, similarly to how ice deliveries were made for ice boxes at the turn of the century. The PM card alerts the mechanic that the occupant is requesting service. The scope of the PM mechanic's work is covered in the FH information packet.

The remaining shops usually do not follow a schedule of cyclic maintenance. Their scope of work includes large-scale repairs. The utility shops perform PM and inspection as often and as regularly as possible, but inspections usually occur when other repairs are being made, and PM is usually done during the off-season.

4 ANALYSIS OF PREVENTIVE MAINTENANCE PROGRAM

Introduction

The analysis of the Preventive Maintenance Program data (primarily IFS data) was limited to a sample of three installations. The investigation focused on current activities to determine whether improvements could be made by either applying new technology and computer automation support or reorganizing operations. The following analysis was generated from the IFS data of the sample installations and other sources as noted; however, it is thought to be closely correlated to, and fairly representative of, PM programs of all nine installations initially interviewed.

General Observations

To evaluate the data properly it is necessary to understand the relationship among sample installations' size, location, age of facilities, function, and Army mission. Fort Bliss had the largest housing population in the sample, with 3642 spaces, guest houses, and 7 VIP quarters. Fort Devens has a smaller population, with 1723 spaces, mobile home parks, and 7 VIP quarters. Fort Eustis is smallest with 1371 spaces, mobile home parks, and 7 VIP quarters. A breakdown of the statistics is given in Table 1.

Table 1*

Relative Physical Size Comparison

		Fort Bliss	Fort Devens	Fort Eustis
Location		TX	MA	VA
Population	Active Duty	21426	5911	8625
	Dependents	9136**	7368	na
Housing	Officers	512	323	361
	NCOs	2458	406	370
	BOQ	606	994	608
	VIP Quarters	7	1	7
	Other	66	30	32

*Adapted from *Guide to Military Installations in the U.S.* (HQDA, 7 April 1986).

**Off-base housing = 14,354.

Although housing capacities do not absolutely determine relative size, they are fairly accurate. Also notable is the geographical and climatic variation of the three sample installations: one Northeast, one Mid-Atlantic, and one Southwest. Fort Bliss and Fort Eustis are Training and Doctrine Command (TRADOC) installations, and Fort Devens is a Forces Command (FORSCOM) installation (see Table 2).

Table 3 compares total FY86 maintenance and repair (M&R) costs with PM costs for each installation. The total cost figures include labor, material, and equipment rental/depreciation for the shops that conduct the maintenance and repair activities.

Table 2

Installation's Army Mission

Fort Bliss, TX	TRADOC Installation: Army Air Defense Artillery, Center and School; Army Sergeants Major Academy; 3rd Armored Cavalry Regiment; German Air Force Training Command and Air Defense School; NATO Nike Training Center; School Bde.; 70th Ord. Bn.
Fort Devens, MA	FORSCOM Installation: Army Intelligence School; 10th Special Forces Group (Airborne); 39th Engineer Bn. (Combat); 36th Medical Bn.; Combat Sup. Bn.
Fort Eustis, VA	TRADOC Installation: Army Transportation School; 7th Trans. Group; Training Support Center; Applied Technology Lab.; Army Aviation Logistics School

*Adapted from *Guide to Military Installations in the U.S.* (HQDA, 7 April 1986).

Table 3

Total Costs for Maintenance and Repair

	Total M&R (in millions of dollars)	Total PM (in millions of dollars)	% PM
Fort Bliss	27.155	0.740	2.7
Fort Devens	17.356	1.004	5.8
Fort Eustis	16.034	1.573	9.8

The total cost includes all PM and M&R for buildings, structures, FH, TH, and utilities. Resources invested in PM varied widely among installations for several reasons:

- condition/age of facilities,
- scope of work accomplished under PM,
- contribution to the SH, and
- extent of renovation under way at the installation.

This study does not attempt to reconcile the differences in PM investment or to validate the reported costs independently. The largest portion of PM costs is labor: Fort Bliss, 78.7 percent; Fort Devens, 63.9 percent; and Fort Eustis, 63.5 percent. The details of PM costs are given in Table 4.

Self-Help

Cost data analysis disclosed that a significant effort was expended accomplishing self-help tasks. These tasks are defined by USACERL as the responsibility of FH and TH occupants. The average installation PM investment in SH averaged $117,738 per year. As a percentage of the PM budget, the SH investment varied from 3.5 to 18.9 percent. These figures are representative, and several million dollars more PM work could be accomplished each year if SH were fully implemented (see Table 5).

Maintenance and Repair

Table 6 lists maintenance and repair costs of housing at the three sites. This information is presented to compare and to evaluate the magnitude of the program in the housing area only.

Table 4

Total Preventive Maintenance Costs

	Fort Bliss	Fort Devens	Fort Eustis
PM Shop Labor	$581,853	$641,374	$999,229
PM Shop Material	109,535	281,012	449,529
PM Shop Equipment Rental	49,187	81,705	75,065
PM Shop Equipment Depreciation	51	13	688
PM total	$739,626	$1,004,104	$1,572,511
Percentage Distribution			
% Labor	78.7	63.9	63.5
% Material	14.8	28.0	28.6
% Equipment	6.5	8.1	7.9

Table 5

Cost of PM Program Executing Self-Help

Labor Costs (Annual) (In U.S. dollars)	Fort Bliss	Fort Devens	Fort Eustis
Total cost of PM mechanics doing SH in FH	$112,143	$126,079	$31,655
Total cost of PM mechanics doing SH in TH	$27,838	$31,367	$24,134
Total cost of PM mechanics performing SH tasks	$139,981	$157,446	$55,789
Total cost of PM (Table 8)	$739,626	$1,004,104	$1,572,511
Percentage of labor costs spent doing SH tasks	18.9	15.7	3.5

Table 6

Housing Maintenance and Repair Costs

	Fort Bliss	Fort Devens	Fort Eustis
Family Housing (FH)	$ 1,526,120	$ 1,278,087	$ 863,351
Bachelor Housing (TH)	5,399,299	4,299,079	3,312,622
Housing total	6,925,419	5,577,166	4,175,973
Total (all real property)	$27,155,645	$17,355,695	$16,034,448
Housing % of total	25.50	32.13	26.04

Table 7 shows the relative M&R costs per square foot of housing in FH and TH, per Family Housing Unit (FHU), and per person housed. Population figures for active duty personnel are taken from Appendix C, Table C1; housing maintenance costs are taken from Table 6. The family housing cost per square foot is, at all three sites, considerably less than the troop housing (TH) cost. However, the perspective on maintenance cost changes when the cost per active duty person is compared to the cost per square foot of housing. The percentage of variation between installations is less when comparing the cost per person housed in either family or troop facilities than it is when comparing the cost per square foot of housing. Table 7 also indicates that the cost to maintain housing facilities varies significantly among the three installations.

Table 7

Unit M&R Costs

	Fort Bliss	Fort Devens	Fort Eustis
Family Housing area (sq ft)	4,806,000	2,412,000	2,043,000
Cost/sq ft	$0.32	$0.53	$0.42
Cost/FHU	$426.79	$741.78	$644.77
Troop Housing area (sq ft)	3,899,000	1,857,000	1,850,000
Cost/sq ft	$1.39	$2.32	$1.79
Cost/person	$302.48	$1,026.52	$454.66

Organization

The cost profile on PM team operations at three installations is shown in Figures 3 and 4. The team is treated as a subset of the shop work force and is allowed to vary during the year. The overall DEH shop work force is relatively stable, but the capability of the team is allowed to vary during the year for the following reasons:

- Capability is usually low in October due to funding uncertainty;

- PM personnel (mechanics) are assigned to other shops to perform emergency and/or other M&R work based on work priority. During peak PM periods more shop labor is invested in PM team activities; and

- During the prime months for relocating military families, the PM team is expanded to meet the work load of preparing vacated housing units before new occupants move in.

Operations

Each of the surveyed installations has a distinct operations approach to PM, as the following sections describe. The information is presented only to compare data, not to evaluate a given program.

Table 8 shows quantitative differences in PM task codes among the three installations. The impact of these variations will be discussed in the following text. (Appendix B lists high-frequency tasks, and Appendix C lists high-cost tasks.)

Fort Bliss

The Fort Bliss PM Team work load consists of 209 tasks, of which 36 are considered high frequency, that is, performed more than 100 times during FY86. Table 9 lists tasks most frequently performed. The portion of this work performed for FH and TH cannot be determined from IFS data.

Fort Bliss has 36 high-duration task codes (longer than 1 hour to complete), or 17 percent of the total.

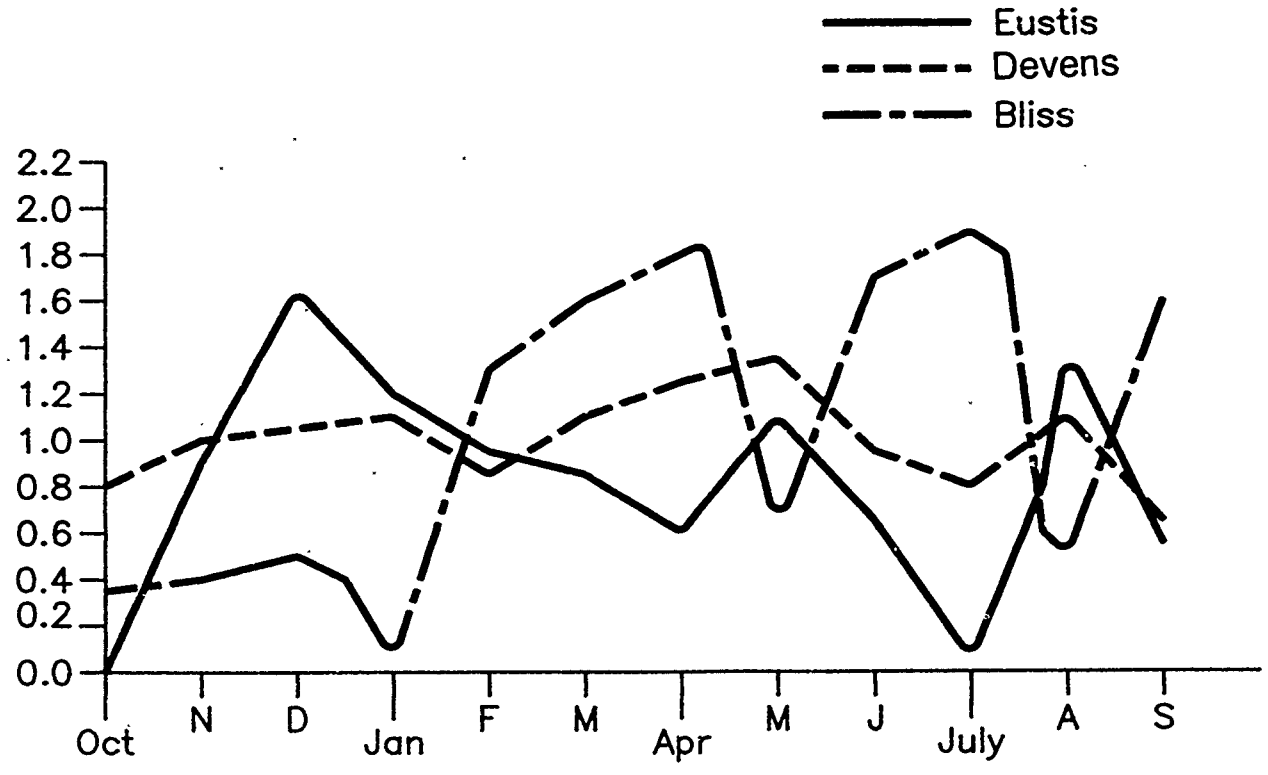


Figure 3. Labor costs for utilities.

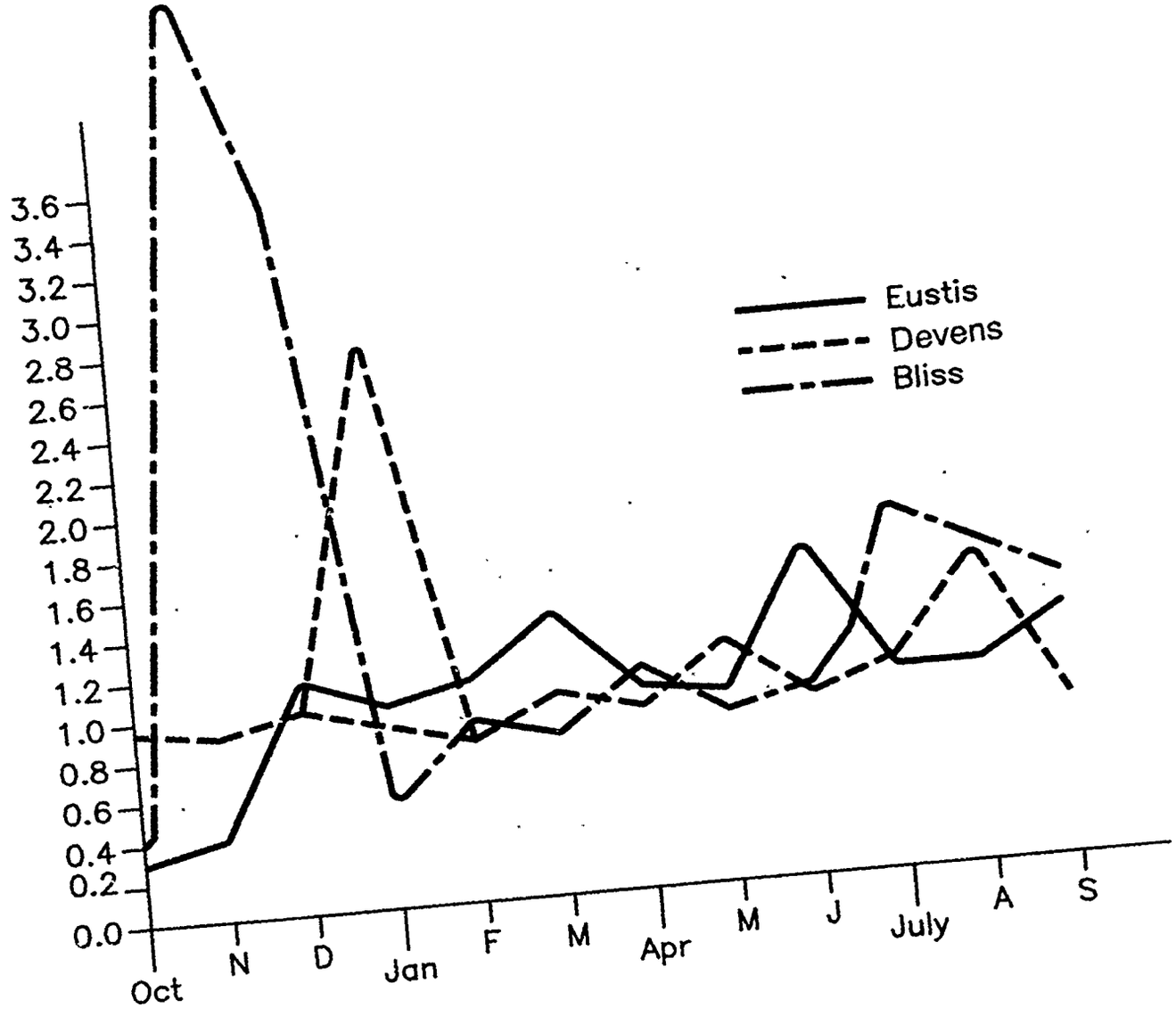


Figure 4. Labor costs for buildings and structures.

Fort Devens

PM Task frequency at Fort Devens is very high because significantly fewer codes are used. The PM team reported 11 tasks (out of a total of 88) performed more than 1000 times during FY86. Table 10 lists the tasks most frequently performed.

The next six high-frequency tasks were resecure/rehang wood doors, replace sliding glass doors, repair flush valve/ball cock, repair aluminum combination handles, trim doors to fit, and repair door knobs. High-frequency tasks account for 22 percent of the total PM team cost.

Table 8

Preventive Maintenance Task Codes

	Fort Bliss	Fort Devens	Fort Eustis
Total (all PM)	209	110	294
High frequency	36	20	91
High duration	35	11	40
High cost	5	6	43

Table 9

Fort Bliss High-Frequency Tasks

Frequency	Description	Unit Cost	Total
6958	Make key from sample (one side)	$0.84	$5,853
2623	Repair interior door and hardware	10.78	28,275
2323	Repair cylinder lockset	14.19	32,956
1243	Repair lavatory faucets	7.72	6,958

*Note that the same shop has an average lockset replacement cost of $18.28, or $4.09 additional.

Table 10

Fort Devens High-Frequency Tasks

Frequency	Description	Unit Cost	Total Cost
6224	Repair faucet leak	$6.37	$39,655
5092	Patch sheetrock wall (1 sq ft)	2.04	10,379
2383	Repair vinyl floor tile (1 sq yd)	4.33	10,319
2247	Free sticking window	3.96	8,899
1866	Replace/install door knobs	11.25	20,999

Time required to accomplish tasks tended to be shorter at Fort Devens than at Fort Bliss. Eleven tasks require 1 hour or more to complete. Table 11 lists tasks taking longest to complete.

Differences in accounting and reporting procedures prevent directly comparing installations on task frequency and duration.

Fort Eustis

The Fort Eustis PM team work load consists of 294 tasks, of which 20 were performed more than 100 times during FY86. Total cost of high-frequency tasks was $39,888, or 2.5 percent of the total team cost. Table 12 lists tasks most frequently performed. (Appendix D is a composite list of high-frequency tasks for the three installations.) According to this data, high-frequency tasks do not significantly impact the total cost of the preventive maintenance effort.

Also, the time to complete each task was investigated. At Fort Eustis, 89 percent of all tasks required less than 2 hours to complete; 65 percent, less than 1 hour. Table 13 lists the tasks requiring the longest time to complete.

About 28 percent, or $191,895, of the total cost of PM at Fort Eustis is spent accomplishing tasks that should belong in the self-help program. Of this total, labor was 78.6 percent, materials costs were almost 16 percent, and the remainder was for equipment rental. Depreciation cost was insignificant. A few PM tasks are performed by other units, notably the carpentry shop.

Task List Analysis

Standard task lists (Appendix A) were collected from each installation to identify the tasks performed, the scope of the work, and standard times allotted to each task. The list also allows comparing the scope of PM activities at each installation. However, several problems were soon noted. The level of detail of task description varied significantly among installations, making comparison difficult. For example, Fort Bliss allots 2.5 hours to "Replace interior door and hardware," whereas Fort Eustis lists several tasks that could be included in the same job:

Replace interior door and hardware	1.5 hours
Replace swinging door	3.0 hours
Install door hinges	0.8 hours
Replace door handles/pulls	0.7 hours
Replace door stop (molding)	0.9 hours.

Thus, Fort Bliss charges all replacement work on interior doors and hardware to the single general purpose work item. But Fort Eustis notes a difference between interior doors and swinging doors and provides work descriptors for replacing only some of the hardware. Moreover, this breakdown could mean that a new interior door with hardware should be installed whenever more than two pieces of hardware need to be replaced. In a separate example, the installation charges the same number of hours for repairing or replacing venetian blinds. This suggests that replacing broken blinds is as economical as repairing them.

Table 11

Fort Devens High Time-Duration Tasks

Description	Hours	Total Cost
Replace 3 by 5 ft picture window	1.52	$29.52
Resecure, align, and repair screen door	1.48	25.22
Install metal door	1.38	23.58
Replace steel sash	1.23	21.20
Repair and resecure door	1.11	19.20
Replace up to 3 sq ft of wood sash	1.11	19.13

Table 12

Fort Eustis High-Frequency Tasks

Frequency	Description	Unit Cost	Total Cost
1029	Replace lavatory faucets	$5.60	$5,760
784	Re-lamp incandescent fixtures	4.21	3,299
546	Replace storm door closers	11.01	6,011
489	Replace cabinet catches	4.45	2,176
400	Secure handrails	7.29	2,917

Table 13

Fort Eustis High Time-Duration Tasks

Description	Hours	Cost
Replace exterior door and hardware	4.45	$69.80
Replace water closet	3.14	54.93
Repair wood siding (50 sq ft)	2.50	41.42
Prepare surface for painting (50 sq ft)	2.47	38.39
Replace floor door closer	2.30	36.61
Replace screening on porch	2.21	38.39

The lists indicate that each installation performs a different combination of tasks. Although all tasks listed appear to be within the scope of activities given in the TM 5-600 series, none of the installations perform all tasks.

It was confirmed by telephone conversation that some installations do not record inspection time; instead, inspection times are included with the repair times. Available data was inadequate to determine which inspections were made and how long it took to complete the inspection tasks.

Installations handle miscellaneous and nonproductive charges in various ways. For example, one installation routinely reports time spent for travel, breaks, standby, and administrative tasks. In addition, some installations list tasks but not estimated durations.

Management

PM is managed differently by each of the three sample sites, and the PM philosophy of the respective administrators varies significantly. Some examples of these differences include the following:

- Redirecting the effort of the PM crews by assigning temporary or emergency maintenance and repair work.
- As a matter of policy, having PM crews inspect and repair instead of having them inspect and report for others to repair.
- Closely managing PM crews versus allowing crews to have broader responsibility for inspecting, reporting, and repairing.
- Establishing a lenient policy concerning PM crew performance of SH tasks.
- Providing or failing to provide strong command support.
- Providing or failing to provide advanced technology.

These factors would not prevent compliance with the regulations, but they would affect the spirit and degree of compliance.

Installations use their PM teams in several ways. In one approach the PM teams work in the military family housing areas and respond to residences displaying a sign in the window. The worker performs all tasks within his ability and prepares work orders for other tasks. This technique has been successful and is popular with military families. However, workers schedule their own time and decide which tasks should be accomplished.

In general, the installations are doing what is required of them under AR 420-22, supplemented by MACOM guidance. However, fiscal problems restrict all aspects of the PM Program. All managers and supervisors interviewed indicated that more resources would facilitate a better PM Program.

What remains to be done is an analysis of PM Program effectiveness and efficiency. But this will be difficult to accomplish because the necessary data are either not being recorded or do not exist in a form capable of analysis. A proper analysis of the PM Program must address questions such as the following:

Do the tasks being performed affect the ability to detect and correct incipient failures?

What happens if inspection cycles are lengthened or shortened?

How do replacement costs compare with repair costs?

Is it cost-efficient not to inspect certain items, but to repair or replace them when they fail?

Is it economical to replace an entire class of items (e.g., light bulbs) instead of replacing them one at a time?

Some installation managers attempted to adjust conditions in the PM program; however, these efforts have had very inconsistent results because they were based on insufficient analysis.

As stated earlier, PM teams typically are not performing the inspections required by AR 420-22, but are performing repair and maintenance tasks, including an amount of SH work which exceeds AR 420-22 requirements. A significant cost reduction has been realized by having PM workers perform repair and maintenance instead of requiring them to perform work for other shops. As fiscal constraints limit PM operations, inspection and testing are being reduced in scope and breakdown repair is increasing.

Recordkeeping

Site visits were made to observe crew operations and to interview supervisors. In general, it was found that records are kept by crew members primarily to justify their working time. The time intervals recorded, however, relate minimally to time spent performing tasks. In one case, for example, a worker was observed performing six tasks during the first hour of work but reported only nine tasks for the entire day. As a result, this kind of recordkeeping cannot be used to evaluate PM operations.

Training

PM mechanics are well trained and competent. The mechanics hired are already skilled, and senior mechanics and other staff train them on unique aspects of Army work.

5 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Based on a detailed analysis of preventive maintenance at several Army installations, it can be concluded that the program works fairly well. As funding levels for PM decrease, however, more work must be accomplished with fewer resources.

2. Typically, PM work is not given priority, and PM is delayed while workers are assigned higher priority work. Managers lack information necessary to identify the most cost-effective activities for establishing priorities. While it is recognized that some M&R activities are given priority for other than economical reasons, the relative values of competing activities can only be generally estimated.

3. PM teams are performing too many self-help tasks for family and troop housing occupants. This reduces the already limited resources for PM work. According to the records of one installation, the DEH could perform over $100,000 more PM work annually if SH tasks were eliminated.

4. Many technical publications supporting PM are obsolete. The TM 5-600 series of technical manuals regarding inspection and preventive maintenance is inadequate for today's requirements.

5. Some installations have effectively reduced costs by not performing PM inspections but instead concentrating on breakdown repair and maintenance. While this practice is somewhat effective, it reduces the opportunity to identify and repair problems at an early stage.

6. Little uniformity in PM programs exists among installations. Differences appear in the tasks performed, priority systems, organization structures, and recordkeeping procedures. Each installation has a unique set of task codes or descriptions. Some do not perform inspections, others perform inspections but charge time to repair activities and others (not the three referenced installations) perform and charge for inspections. Miscellaneous and nonproductive time charges are handled in different ways.

7. Collected field data appear to be generally inaccurate, making management decisions difficult. The emphasis has been accounting for workers' time rather than recording the work actually accomplished.

8. Management control of field activities varies from monitoring and directing the work to minimal control in giving most of the daily responsibilities to the workers accomplishing the tasks.

Recommendations

1. PM activities should be analyzed using return-on-investment (ROI) techniques to determine whether the task should be accomplished and the relative value of the task, and to prioritize work load. This process will also identify activities that should be eliminated in future operations. Other installations should share in the analysis and decisions made at any given installation.

2. Program changes indicated by the ROI analysis should be tested or evaluated before recommending their implementation throughout the Army.

3. Task codes or descriptions should be standardized to simplify entry of field data, better provide understanding of content, simplify recordkeeping, and facilitate operational improvements. Standardization, such as bar code reading devices, is essential before automation.

4. Recordkeeping and accounting procedures should be standardized to improve managers' evaluation of program effectiveness.

5. A system similar to the MMS should be developed to manage PM activities related to buildings and structures, including an automated data entry system. This program should handle resource scheduling, activity scheduling, data collection, analysis, and report generation and be an interactive interface to Army standard systems.

6. The feasibility of applying artificial intelligence technology to the Preventive Maintenance Program through the use of an expert system to the Preventive Maintenance Program should be investigated.

7. The manuals in the TM 5-600 series pertaining to PM activities should be reviewed and updated. Consideration should be given to the use of more active training materials such as videotapes to increase effectiveness of the media.

ABBREVIATIONS

AR:	Army Regulation
CA:	Commercial Activities
CONUS:	Continental United States
DA:	Department of the Army
DEH:	Directorate of Engineering and Housing
DOD:	Department of Defense
EHSC:	Engineering and Housing Support Center
EPS:	Engineered Performance Standards (TB 420 series)
FH:	Family Housing
FHU:	Family Housing Unit
FORSCOM:	Forces Command
IFS:	Integrated Facilities System
IJO:	Individual Job Order
MACOM:	Major Command
MES:	Management Engineering System
MMS:	Maintenance Management System
M&R:	Maintenance and Repair
PAM:	Pamphlet
PM:	Preventive Maintenance
PWD:	Public Works Division
ROI:	Return on Investment
RPMA:	Real Property Maintenance Activity
SH:	Self-Help
TH:	Troop Housing (bachelor or unaccompanied)
TM:	Technical Manual
TRADOC:	Training and Doctrine Command
USACE:	U. S. Army Corps of Engineers
USACERL:	U. S. Army Construction Engineering Research Laboratory

APPENDIX A:

STANDARD PM TASK LIST FOR DOORS*

Task Description	Fort Bliss		Fort Eustis		Fort Devens	
Door, Door Frame, Doorbell and Panic Hardware Work	*Code*	*Time*	*Code*	*Time*	*Code*	*Time*
Repair interior door and hardware	AA	0.5	EO	0.6		
Replace interior door and hardware	AB	2.5	E5	1.5		
Repair exterior door and hardware	AC	1.0				
Replace exterior door and hardware	AD	1.5	E3	3.1		
Repair exterior wood storage door			F4	1.1		
Repair door closer and door bell	AE	0.5				
Replace door closer and door bell	AF	1.0				
Replaçe aluminum combined door closer					13	0.0
Repair panic hardwarwe	AG	1.0				
Replace panic hardware	AH	2.5				
Repair wood/aluminum threshold	AI	0.5				
Replace wood/aluminum threshold	AJ	1.0			32	0.0
Replace threshold (door)			JO	1.1		
Repair interior door jamb trim	AK	1.0	G2	0.9		
Replace interior door jamb trim	AL	2.5				
Repair exterior door jamb trim	AM	0.8				
Replace exterior door jamb trim	AN	4.0				
Repair exterior double door jamb	AO	0.9	F5	0.7		
Replace exterior double door jamb	AP	1.0	F6	3.7		
Repair screen door/hardware 1 each	AQ	1.0	I6	1.0		
Replace screen door/hardware	AR	2.0			45	0.0
Repair shower door 1 each	BC	1.0				
Repair overhead door	C1	0.8				
Repair rails for sliding door	C2	1.7	E2	0.5		
Repair closet door			68	1.4		
Replace closet door guides			J3	0.4		
Replace by-pass closet door			E7	5.0	39	1.0
Repair by-pass closet door track			I0	0.4		
Replace by-pass closet door track			I1	3.5		
Repair bi-fold closet door track			I2	0.5		
Replace bi-fold closet door track			I3	1.2		
Replace bi-folding door			E9	2.4		
Adjust bi-folding door			E8	1.0		
Adjust closet door			E6	0.8		
Replace sliding glass door					31	0.0
Adjust sliding glass door						
Repair swinging door			F0	1.12		
Replace swinging door			F1	3.0		
Repair according door			F3	2.0		
Resecure/realign/repair panic hardware					25	4.3
Repair/resecure door					26	0.0

*Appendix compiled from IFS data.

Task Description	Fort Bliss	Fort Eustis		Fort Devens	
Install metal door				27	0.0
Resecure/rehang wood door				30	0.0
Cut off door bottom, 1 each		F8	0.6		
Trim door to fit		F9	0.4	21	0.0
Install door louver		G1	0.7		
Install door hinges, 1 set		G0	0.8		
Replace door stop (moulding), 17 1F		G3	0.9		
Lubricate builders hardware		G9	0,6		
Replace door handles/pulls		H6	0.7		
Install door savers		I4	0.9		
Replace door weatherstripping		I5	0.8	A7	0.5
Caulking doors/windows		J7	0.9	A6	0.5
Base rubber replacement, 4 ft				01	0.0
Align/adjust storm doors		I8	0.7		
Install door bottom sweep		I9	0.5		
Cut door bottom/raise threshold		J1	1.3		
Replace glass in wood door		J5	1.2	17	0.0
Replace glass in metal door		J6	1.3	18	0.0
Replace glass in plate glass in door				16	0.0
Remount/replace window unit		F7	1.0		
Repair door knob				23	0.0
Replace/install door knob				24	0.0
Repair/replace wooden door jamb				28	0.0
Repair/replace door/window jamb				29	0.0

APPENDIX B:

HIGH FREQUENCY TASK LIST FOR FORTS BLISS, DEVENS, AND EUSTIS

Repair Door Knob
Replace/Install Door Knob
Aluminum Combination Clip/Locknut
Repair Cylinder Lockset
Cut Key From Sample (Single-Sided)
Replace Closet Door Hanger
Repair Interior Door and Hardware
Plane (To Fit) Door
Resecure/Rehang Wood Door
Repair/Replace/Realign/Adjust Sliding Door
Patch Hole in Sheet Rock, 1 sq ft
Replace 1 to 10 Pieces of Asphalt Floor Tile
Replace Suspended Ceiling Panel
Repair/Replace Towel Rack
Caulk Around Bathtub
Repair Flush Valve/Ballcock
Repair Faucet Leak
Repair Lavatory Faucets
Replace Seat Washer 'O' Ring
Unplug Tub
Replace Fire Alarm Battery
Relamp Incandescent Light Fixture
Relamp Fluorescent Fixture
Erase Window Free

APPENDIX C:

HIGH COST TASK LIST FOR FORTS BLISS, DEVENS, AND EUSTIS

Repair Interior Door and Hardware
Repair Cylinder Lockset
Repair Door Knob
Repair/Replace Aluminum Combination Storm Door Handle
Replace up to 36 sq in. of Wood Sash
Resecure/Rehang Wood Door
Repair Door Jamb
Repair/Replace/Realign/Adjust Sliding Door
Replace 1 to 10 sq ft of Asphalt Floor Tile
Repair Plaster 10 to 20 sq ft
Caulk Around Bathtub
Repair Flushometer
Repair Flush Valve/Ballcock
Replace P-Trap
Replace Pipe Fitting
Repair Faucet Leak
Repair Lavatory Faucets
Unplug Bathtub
Replace Outlet Cover Plate
Relamp Incandescent Light Fixtures

USACERL DISTRIBUTION

Chief of Engineers
ATTN: CEHEC-IM-LH (2)
ATTN: CEHEC-IM-LP (2)
ATTN: CECC-P
ATTN: CECW
ATTN: CECW-O
ATTN: CECW-P
ATTN: CECW-RR
ATTN: CEMP
ATTN: CEMP-C
ATTN: CEMP-E
ATTN: CERD
ATTN: CERD-L
ATTN: CERD-C
ATTN: CERD-M
ATTN: CERM
ATTN: DAEN-ZCE
ATTN: DAEN-ZCI
ATTN: DAEN-ZCM
ATTN: DAEN-ZCZ

CEHSC
ATTN: CEHSC-ZC 22060
ATTN: DET III 79906
ATTN: CEHSC-F 22060
ATTN: CEHSC-TT-F 22060
ATTN: CEHSC-FE-B 22060

US Army Europe
ODCS/Engineer 09403
ATTN: AEAEN-FE
ATTN: AEAEN-ODCS
V Corps
ATTN: DEH (11)
VII Corps
ATTN: DEH (16)
21st Support Command
ATTN: DEH (12)
USA Berlin
ATTN: DEH (9)
Allied Command Europe (ACE)
ATTN: ACSGEB 09011
ATTN: SHIHB/Engineer 09055
ATTN: AEUES 09168
USASETAF
ATTN: AESE-EN-D 09019

8th USA, Korea (19)

ROK/US Combined Forces Command 96301
ATTN: EUSA-HHC-CFC/Engr

Ft. Leonard Wood, MO 65473
ATTN: Canadian Liaison Officer
ATTN: German Liaison Staff
ATTN: British Liaison Officer (2)
ATTN: French Liaison Officer

USA Japan (USARJ)
ATTN: DCSEN 96343
ATTN: Facilities Engineer 96343
ATTN. DEH-Okinawa 96331

Area Engineer, AEDC-Area Office
Arnold Air Force Station, TN 37389

416th Engineer Command 60623
ATTN: Facilities Engineer

US Military Academy 10996
ATTN: Facilities Engineer
ATTN: Dept of Geography & Computer Sciences
ATTN: MAEN-A

AMC - Dir., Inst., & Svcs.
ATTN: DEH (23)

DLA ATTN: DLA-WI 22304

DNA ATTN: NADS 20305

FORSCOM (28)
FORSCOM Engineer, ATTN: Spt Det. 15071
ATTN: DEH

HSC
Ft. Sam Houston AMC 78234
ATTN: HSLO-F
Fitzsimons AMC 80045
ATTN: HSHG-DEH
Walter Reed AMC 20307
ATTN: Facilities Engineer

INSCOM - Ch, Instl. Div.
Arlington Hall Station 22212
ATTN: Engr & Hsg Div
Vint Hill Farms Station 22186
ATTN: IAV-DEH
Ft. Belvoir 22060
ATTN: Facilities Engineer (3)

USA AMCCOM 61299
ATTN: AMSMC-RI
ATTN: AMSMC-IS

Military Dist of Washington
ATTN: DEH
Cameron Station (3) 22314
Fort Lesley J. McNair 20319
Fort Myer 22211

Military Traffic Mgmt Command
Falls Church 20315
Oakland Army Base 94626
Bayonne 07002
Sunny Point MOT 28461

NARADCOM, ATTN: DRDNA-F 01760

TARCOM, Fac, Div. 48090

TRADOC (19)
HQ, TRADOC, ATTN: ATEN-DEH 23651
ATTN: DEH

TSARCOM, ATTN: STSAS-F 63120

USAIS
Fort Huachuca 85613
ATTN: Facilities Engineer (3)
Fort Ritchie 21719

WESTCOM
Fort Shafter 96858
ATTN: DEH
ATTN: APEN-A

SHAPE 09055
ATTN: Survivability Sect. CCB-OPS
ATTN: Infrastructure Branch, LANDA

HQ USEUCOM 09128
ATTN: ECJ 4/7-LOE

Fort Belvoir, VA
ATTN: Australian Liaison Officer 22060
ATTN: Water Resource Center 22060
ATTN: Engr Studies Center 22060
ATTN: Engr Topographic Lab 22060
ATTN: ATZA-TE-SW 22060
ATTN: CECC-R 22060

CECRL, ATTN: Library 03755

CEWES, ATTN: Library 39180

HQ, XVIII Airborne Corps and
Ft. Bragg 28307
ATTN: AFZA-DEH-EE

AMMRC 02172
ATTN: DRXMR-AF
ATTN: DRXMR-WE

Norton AFB, CA 92409
ATTN: AFRCE-MX/DE

Tyndall AFB, FL 32403
AFESC/Engineering & Service Lab

NAVFAC
ATTN: Division Offices (11)
ATTN: Facilities Engr Cmd (9)
ATTN: Naval Public Works Center (9)
ATTN: Naval Civil Engr Lab (3)
ATTN: Naval Constr Battalion Ctr 93043

Engineering Societies Library
New York, NY 10017

National Guard Bureau 20310
Installation Division

US Government Printing Office 20401
Receiving/Depository Section (2)

US Army Env. Hygiene Agency
ATTN: HSHB-ME 21010

Nat'l Institute of Standards & Tech 20899

Defense Technical Ino. Center 22304
ATTN: DTIC-FAB (2)